Titanium Oxide Surfaces and Mineral Growth

E. DiMasi (BNL) and C. Orme (LLNL)

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Introduction: A challenge in improving the quality of titanium-based bone implant materials is the interface between the implant and the healing bone, which must withstand significant physical stresses along with a changing electrochemical environment. In such implants, the titanium oxide layer plays a crucial role in encouraging the synthesis between the bone and implant while protecting the underlying Ti metal. Atomic force microscopy studies using a controlled electrochemical environment have shown that the native oxide on dry titanium consists of domes, which coarsen and grow after immersion in phosphate buffered saline. As the potential is increased to -2 volts, calcium phosphate minerals rapidly nucleate on the surface [1]. The information obtained by microscopy suggests many questions about the structure of the oxide and mineral films: What is the lateral correlation length; does it change under hydration? Is there a transition from amorphous to crystalline calcium phosphate as the film grows? Are there changes at the interface between the titanium and oxide layers?

Results: To address these questions we have conducted x-ray reflectivity measurements of dry substrates consisting of 560 nm thick titanium films sputtered onto a Si wafer [2], having a native oxide about 2 nm thick. Unfortunately, reflectivity from these samples is dominated by the interference pattern produced by the texture of the Ti film, which was sputtered in bursts producing slight dips in the density at 2.7 nm spacings. Further work on this project will depend upon identifying more uniform titanium oxide substrates. Ultimately, we aim to conduct *insitu* X-ray studies on samples in an electrochemical environment.

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References:

[1] J. Bearinger, C. Orme, and J. Gilbert (in preparation).
[2] Samples were made by T. Barbee (LLNL).

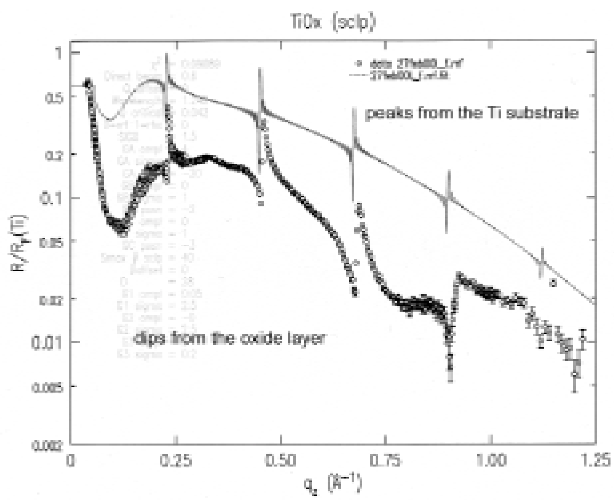

Figure 1. X-ray reflectivity from a titanium film on silicon (circles). Dips in the reflectivity at 0.1 Å^{-1} and 0.8 Å^{-1} are presumably due to the native oxide layer. This structure is effectively obscured by the intense interference peaks caused by the nonuniform texture of the underlying Ti film, as determined by the model (solid lines).